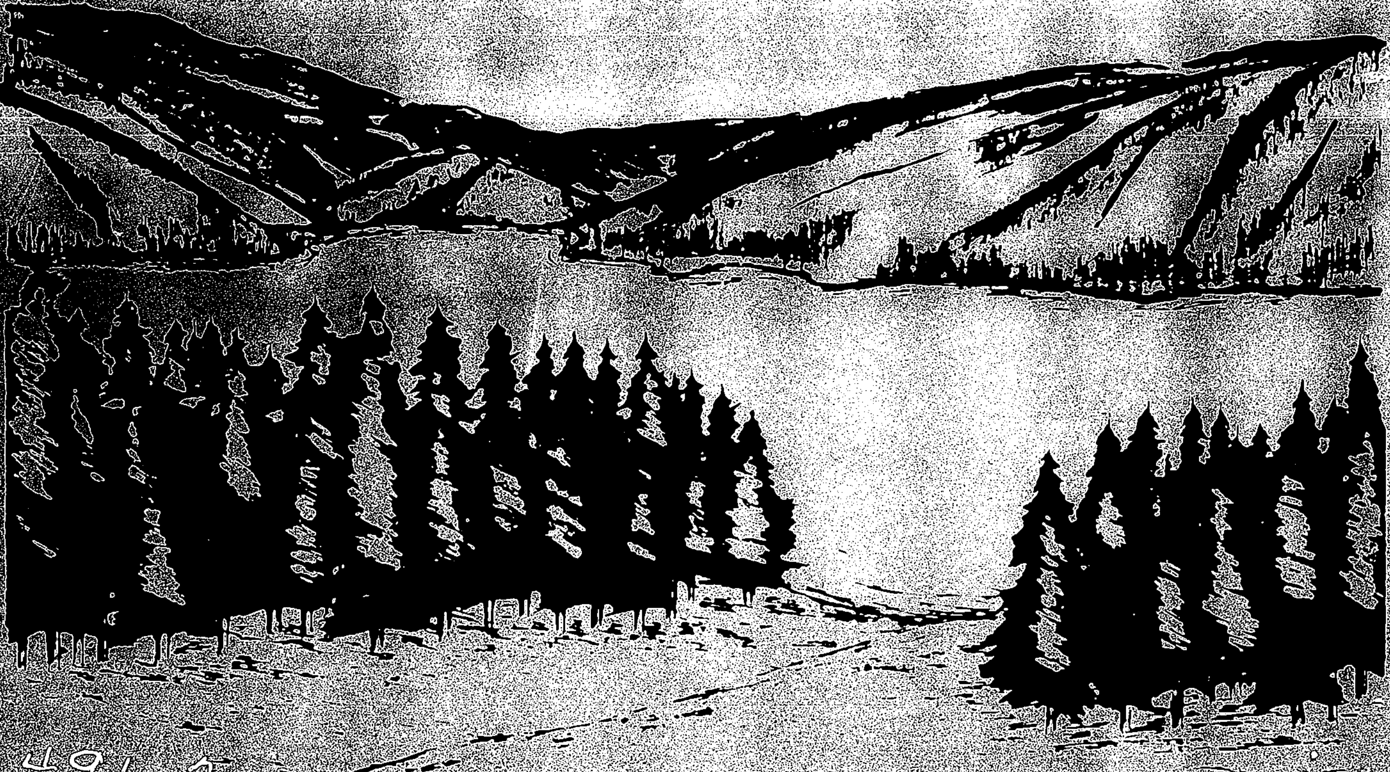
WATERSHED WORK PLAN

Upper Llagas Creek

Santa Clara County, California September 1967



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WATERSHED WORK PLAN

UPPER LLAGAS CREEK WATERSHED

Santa Clara County, California

Prepared under the authority of the
Watershed Protection and Flood Prevention Act
(Public Law 566, 83rd Congress; 68 Stat. 666), as amended

Prepared by

Loma Prieta Soil Conservation District
Santa Clara County Flood Control and Water District
South Santa Clara Valley Water Conservation District

With assistance by

Resources Agency of California, Department of Conservation
Division of Soil Conservation
Division of Forestry
and
United States Department of Agriculture
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September 1967

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PROJECT MAP

WATERSHED WORK PLAN

UPPER LLAGAS CREEK WATERSHED
Santa Clara County, California

September 1967

SUMMARY OF PLAN

The portion of the Llagas Creek Watershed included in this work plan contains approximately 35,000 acres in south central Santa Clara County. It is the upper half of the Llagas Creek Watershed including Little Llagas Creek and its tributaries. The lower part of the watershed is included in the Lower Llagas Creek Watershed Project for which a separate work plan is being prepared by the sponsors for concurrent submittal.

The works of improvement to be installed on the Upper Llagas Creek Watershed are interdependent with those on the lower watershed. To obtain maximum benefits for either project, the channel improvements proposed for this lower project must be completed before the improvements proposed for this project are installed.

Llagas Creek drains portions of the south Santa Clara Valley and the Santa Cruz Mountains. It is tributary to the Pajaro River which discharges into the Pacific Ocean at Monterey Bay. Morgan Hill and San Martin, the urban centers within the watershed, are reflecting the impact of rapid urban growth due to their proximity to San Jose, one of the fastest growing metropolitan complexes in the United States. However, the predominant land use within the watershed is agricultural.

Major flooding has inundated large areas within the watershed 12 times in the last 60 years. Historically, about 930 acres of valuable cropland, residential property, and commercial development have been inundated by a single flood. Nearly every portion of the floodplain has been subjected to lesser floods at one time or another.

The sponsors propose to solve the flood problem through the application of both land treatment and structural measures. The land treatment program includes on-farm measures and intensified fire protection on the brush and forest lands. The structural works include improving or constructing 15 miles of channels on Llagas Creek and Little Llagas Creek and its tributaries. An existing water conservation reservoir will be modified to provide flood detention storage. All structural measures will be designed to contain the 1-percent flood, that is, a flood that will be equaled or exceeded once in a hundred years.

The total installation cost of land treatment and structural measures is $5,829,100 of which $3,325,300 or 56 percent, will be from Public Law 566 funds. The remaining $2,503,800, together with $19,700 annual operation and maintenance cost, will be borne locally. It is anticipated that $230,100 will be expended the first year and $1,140,900, $122,300, $417,100, $1,476,600, $1,444,100, and $998,000 respectively, during the subsequent years of a seven-year period.

This seven-year installation period is integrated with the Lower Llagas Creek Project installation schedule.

The total average annual cost of the structural measures, including the amortized cost of installation plus operation and maintenance costs is $193,800. Comparing this with total average annual benefits of $382,700 yields a benefit-cost ratio of 2.0 to 1.0.

This work plan is jointly sponsored by the Santa Clara County Flood Control and Water District, the South Santa Clara Valley Water Conservation District, and the Loma Prieta Soil Conservation District. The Santa Clara County Flood Control and Water District will be the local agency responsible for project installation and operation and maintenance.

Land treatment measures, other than those for fire protection, will be installed and maintained by individual farmers and ranchers cooperating with the Loma Prieta Soil Conservation District. The Santa Clara County Flood Control and Water District will carry out the intensified fire protection plan with assistance from the California Division of Forestry and the U. S. Forest Service.

The above agencies participated in the technical planning together with the Soil Conservation Service of the United States Department of Agriculture and the Division of Soil Conservation of the Department of Conservation of the Resources Agency of California.

DESCRIPTION OF WATERSHED

PHYSICAL DATA

Santa Clara Valley extends from the southern tip of San Francisco Bay to Hollister about 50 miles to the southeast. The northern portion of the valley drains into San Francisco Bay. The valley from the City of Morgan Hill south, drains through Soap Lake into the Pajaro River which flows westward about 22 miles into Monterey Bay near Watsonville. Soap Lake is a low lying floodplain which is inundated by local drainage and the Pajaro River during periods of high runoff. Llagas Creek above the confluence with Little Llagas Creek drains 18,600 acres. The remainder of the 35,000 acre watershed is in the Little Llagas Creek Watershed. (See Project Map).

Llagas Creek has its headwaters on the densely wooded slopes of Mount Chuai in the Santa Cruz Mountains approximately 11 miles upstream from Chesbro Dam. Chesbro Reservoir provides 7,630 acre-feet of conservation storage and covers an area of 275 acres. The drainage area above the reservoir is about 12,100 acres. Below the dam, Llagas Creek flows another six miles through orchards and vineyards in Paradise Valley, into the south Santa Clara Valley.

Beginning near the U. S. Highway 101 crossing, Llagas Creek winds its way through a highly pervious area east of San Martin where controlled releases from Chesbro Reservoir are percolated into the ground water basin. The confluence with Little Llagas Creek four miles downstream from the highway crossing establishes the lower limit of the Upper Llagas Creek Watershed Project. In the final nine miles to the Pajaro River, Llagas Creek intercepts several small tributaries from the east and Miller Slough from the west. Altogether, it is about 30 miles from Mount Chuai to the Pajaro River along Llagas Creek.

Little Llagas Creek is the major tributary to Llagas Creek in the Upper Llagas Creek Watershed. Its headwaters are in the sparsely wooded, grass covered foothills about two miles northwest of the City of Morgan Hill.

Little Llagas Creek reaches the valley floor in less than a mile and then follows a well defined channel through the City of Morgan Hill and across agricultural land. In the eight miles from Morgan Hill to its confluence with Llagas Creek, Little Llagas Creek intercepts Corrallitos Creek from the east and several smaller unnamed watercourses.

About 35 percent of the Upper Llagas Creek Watershed is in the Santa Clara Valley floor. This area is two to three miles wide, seven miles long and ranges in elevation from 230 feet to 400 feet above sea level. It is mostly devoted to the production of prunes, strawberries and intensively cultivated crops which are irrigated by pumped ground water. At present, less than 5 percent of the valley floor is devoted to urban uses.

East of the valley floor, steep, lightly vegetated hills rise to 1,600 feet in elevation. This part of the watershed, about 15 percent of the total area, is range and brushland.

The remaining 50 percent of the watershed is located west of the valley floor in the foothills of the Santa Cruz Mountains. These hills are similar to the east side hills in their lower elevations, but become progressively more densely wooded as the elevation increases to 3,562 feet at the peak of Mount Chuai. The predominant native cover is brush, although minor areas, particularly on shallower soils, are grasslands.

The soils of Upper Llagas Creek Watershed can be divided into three types on the basis of origin: (1) residual soils, (2) those soils overlying older alluvium, and (3) the soils associated with the younger alluvium.

The residual soils found in the uplands have developed in place on, and are derived from the older rocks of the watershed. These soils are shallow to moderate in depth and are underlain directly by bedrock, usually sandstone, shale or serpentine. Although the soils overlying the serpentine are generally heavy textured, medium texture predominates among the soils derived from the sedimentary rocks.

The soils formed on older alluvial deposits are deep although several of the soils series in the category contain a claypan. Medium texture predominates in these series which occur as terraces and high fan deposits along the margins of the Santa Clara Valley and its larger tributary stream valleys.

Soils of the center of the main valley have developed on the younger alluvium. This area is still subject to flooding, therefore many of the soils have no soil profile development. In texture the soils range from medium to coarse grained. Prime agricultural land is closely associated with these soils.

About 45 percent of the entire Upper Llagas Creek Watershed is considered suitable for cultivation, with 35 percent within Classes I and II.

Climate in the Llagas Creek area is typical of central California coastal valleys with warm, dry summers and cool, wet winters.

Mean annual precipitation, almost entirely in the form of rain, varies between 19 inches in the valley area near the mouth of Llagas Creek and 40 inches near the summit of Mount Chuai. About 76 percent of the mean annual rainfall occurs between December 1 and March 31, and 92 percent between November 1 and April 30.

Mean annual temperature is 58°F, with a monthly variation between 66°F in July and 48°F in January. Extreme temperatures in nearby Gilroy have varied between a low of 20°F and a high of 116°F. The average frost free period is 273 days.

ECONOMIC DATA

All the urban and a great majority of the highly developed agricultural land within the watershed is concentrated on the valley floor. The larger land holdings with a lower type of land use are found in the uplands. There is no Federal land within the watershed.

Land use within the watershed is tabulated below:

Land Use	Acres	Percent of Watershed
Urban	300	1
Orchard	10,600	30
Row Crops	300	1
Hay	900	3
Irrigated Pasture	600	2
Other Pasture and Rangeland	15,900	45
Forest and Brushland	6,100	17
Miscellaneous	300	1
TOTAL	35,000	100

Historically, agriculture has been the major industry in the project area. Even with today's trend toward urbanization, the growing, processing, and marketing of farm products account for about 60 percent of the annual income in the watershed.

Nearly one-half of the watershed population lives on 500 separate farm units, most of which are owner operated. About 50 percent of these farms are in the floodplain area.

Farms within the watershed range in size from 5 to 3,300 acres with an average of 20 acres in the valley floor and 100 acres in the uplands. The land is predominantly devoted to prune orchards with small areas in strawberries and other row crops, grains, and hay. Many walnut orchards are located along Llagas Creek below Chesbro Dam. Poultry and cattle raising are quite extensive along the valley fringes.

Average per acre values for the various types of rural land found within the watershed include $1,500 for rangeland, $2,500 for row cropland, and $4,500 for orchard land. The average farm income from these lands ranges from $25.00 per acre for pasture to $850 per acre for pears.

The pressure of urban expansion from the San Jose area to the north is increasing land values far beyond their agricultural worth. Studies by the Santa Clara County Planning Department indicate that agriculture will remain the predominant land use for the next 20 years. More than half the valley floor is expected to still be devoted to agriculture in 1985.

The nonagricultural sector of the area's economy is divided between manufacturing and commerce. Metal products manufacturing is an important industry and includes one of the nation's largest vacation trailer manufacturing plants. Commerce consists of the trade generated by the local population and traffic on U. S. Highway 101.

Urban development, both commercial and residential, is concentrated on the west side of the valley floor along U. S. Highway 101 and the Southern Pacific Railroad. Industrial development is concentrated along the east side of the highway adjacent to the railroad. Most residential areas are east of the highway.

An important factor in this segment of the local economy is the growing number of people who live within the watershed but commute to a place of employment in the San Jose area. Processing plants for products such as prunes, pickles, wine, health foods, and strawberries also contribute substantially to the local economy.

Urban development is expected to continue at an accelerating pace even without flood prevention. By 1985 urban development is expected to more than double in area. According to the Santa Clara County Planning Department, watershed population is expected to increase from the present 7,000 to about 85,000 by the year 2000. Forecasts made by the United States Department of Commerce and the California Department of Water Resources look for even greater amounts of urban development.

Morgan Hill, an incorporated city of 4,000, lies entirely within the watershed. Four miles south of Morgan Hill, the unincorporated town of San Martin, population 1,200, lies on the boundary between the upper and lower project areas. Urban land values range from a low of $4,000 an acre in the more isolated areas to a high of $7,000 an acre near the City of Morgan Hill. Inside Morgan Hill some lands are valued at $2.50 a square foot. An overall average value for urban land in the watershed is in the neighborhood of $6,000 per acre.

An excellent network of all-weather roads serves both agricultural and urban areas. U. S. Highway 101 and the Southern Pacific Railroad place the watershed on the main traffic line between San Francisco and Los Angeles. State Highway 152 traverses the Lower Llagas Creek Project area and connects Gilroy with Monterey Bay to the west and the San Joaquin Valley to the east. In the upper watershed, however, the all-weather road along Llagas Creek has very few feeder roads to provide access to the brush and forest lands.

WATERSHED PROBLEMS

FLOODWATER DAMAGE

Hydrologic studies show that floodwaters from a 1-percent event will inundate about 2,700 acres. Smaller acreages are flooded at more frequent intervals. The flood hazard area includes nearly one-quarter of the valley floor.

Based on information provided by the Santa Clara County Assessor's office, the present value of land and improvements in the watershed is over $65 million. The Santa Clara County Planning Department projects an increase to nearly a billion dollars by 1990.

Flooding occurs about four years out of five, but the greatest part of the average annual damages is associated with the major flooding that occurs about one year out of five. Statistically, three out of four major floods occur in the winter months of December, January, and February, and the other in March or April. Ten major floods have occurred since 1909 with the two most recent having been in 1955 and 1958.

Floodwater damages to agriculture include rotting and other damaging effects to growing crops and delays in planting new crops due to wet field conditions. Damage is also caused to farmlands through the importation of weeds and plant diseases from lands upstream. Debris left by receeding floodwater requires costly clean-up operations. Farm buildings, machinery, and irrigation systems are also damaged by floodwaters.

Shallow flows of floodwaters, debris, and sediment in residential areas would cover lawns, flowers, and shrubs. There would be expensive clean-up, debris removal, replanting, and weed and disease control induced by flood-borne weed seeds and disease. Deeper floodwater and sediment would get into basements, damage foundations, sidewalks, driveways, fences, and other structures.

With a maximum depth of two feet, water and sediment would get into newer homes, especially those with slab-floor construction. When water and sediment enters a house, rugs and upholstered furniture are seriously damaged. Clothes, foodstuff, toys, electrical appliances, and other household effects would also be damaged or destroyed.

Homes in this watershed are increasing in value. There is a great increase in population in this area, and residential development is very active. While a conservative value of housing was used in the damage analysis, actual values are rising from a former range of $4,000 to $30,000 per house to a present range of $20,000 to $60,000 each, as old homes are replaced with modern subdivisions and luxury estate developments.

It has been estimated that a 100-year flood would presently cause about $167,000 damage in the residential area. Due to the rapid development of the residential area, damage in a 100-year flood, 20 years in the future has been estimated at $1,914,000.

In the commercial areas, shallower flood and sediment flows will be more damaging than in residential areas. Floor levels are generally lower and equipment and supplies more greatly damaged due to floor storage. Loss of business is a great item of damage.

The commercial areas are of the service type and much of it highway oriented, such as restaurants, motels, auto agencies, filling stations, launderies, grocery stores, drug stores, clothing stores, and other similar uses. With the rapid population growth and greater travel through the area, the commercial areas will be rapidly expanding.

Values have been estimated to be over $246,600 per acre structural value including contents. A 100-year flood would presently cause about $27,600 damage while the same size flood 20 years hence would result in an estimated commercial damage of $150,000 in this watershed.

Shallow flows of floodwater and sediment cause extensive damage in an industrial area since floors are usually at ground elevation, or lower. Equipment, motors, tools, pits, parts, hoists, and other appliances are damaged extensively by floodwater and sediment. Down-time of equipment results in loss of employment, loss of production, and excessive depreciation of buildings and equipment.

There is a little light industry in the area presently, which is mostly agricultural oriented. In the future, with expansion of the San Jose area industrial complex southward, it is expected that there will be a great expansion of industry along U. S. Highway 101 and the railroad, both of which are centered in the floodplain.

Values of industrial areas have been estimated to be $170,000 structure and contents per acre. It is this low due to large yard storage areas and parking lots. A 100-year flood would presently cause approximately $160,000 while the same size event 20 years in the future would cause an estimated damage of $783,100. There are additional damages to public transportation facilities such as roads and railroads. Interruption of communication and utility services and the general disruption of the area's economy are less tangible damages. The above two types of damage have not been evaluated.

SEDIMENT DAMAGE

The sediment damage is not easily separable from floodwater damage. Agricultural lands are left with layers of silt which either partly damage or totally destroy growing crops. The sediment must be removed in either case, resulting in high costs to the farm operation. Siltation in urban areas result in even higher damages and costs of removal are often very high.

EROSION DAMAGE

Erosion damage is generally confined to areas adjacent to stream channels which are the only significant sediment sources. Under present watershed cover conditions, erosion damage does not present a serious problem. However, with the increasing urbanization and the wildfire threat in the upper watershed, the erosion problem could become more serious if appropriate land treatment measures are not installed.

PROJECTS OF OTHER AGENCIES

In order to alleviate a growing ground water shortage brought on primarily by heavy pumping for irrigation water, the South Santa Clara Valley Water Conservation District built 7,630 acre-foot Chesbro Reservoir on Llagas Creek in 1955. The reservoir functions by holding back runoff and then releasing water downstream slowly so that the entire amount can percolate into the ground. The 3.6 mile reach between U. S. Highway 101 and Masten Avenue is the primary percolation area on Llagas Creek.

In 1958 the District built 10,350 acre-foot Uvas Reservoir on nearby Uvas Creek and a 36-inch pipeline to import water into the Llagas Creek Watershed further supplementing their supply of recharge water. These two reservoirs have been highly successful in achieving the desired objective of supplementing ground water recharge. The sponsors have expressed no desire to develop additional agricultural water at this time because they have negotiated a contract to purchase imported water.

The alignment for the portion of the Route 2 freeway which passes through the Llagas Creek Watershed has been adopted by the California Highway Commission. It is about 3/4 mile east of and generally parallel to existing U. S. Highway 101. The sponsors have consulted with the California Division of Highways and have integrated the works of improvement of this work plan with the freeway planning wherever feasible.

Although the construction schedule for the freeway has not been set, the sponsors hope to coordinate the construction and acquisition of rights-of-way for the two projects. The Santa Clara County Flood Control and Water District will continue close coordination with the California Division of Highways in working out the final details of the two projects.

The United States Army Corps of Engineers has an active investigation in the Soap Lake and Pajaro River area downstream from the mouth of Llagas Creek. Flood control levees along the Pajaro River in the vicinity of Watsonville are already constructed. Based on hydrologic studies, the inclusion of flood control storage within Chesbro Reservoir offsets any adverse effects channelization will have on downstream flood peaks. The Corps was consulted in the preparation of this work plan.

BASIS FOR PROJECT FORMULATION

The objective of the studies conducted on the Llagas Creek Watershed is to formulate a plan of improvements to alleviate flooding and to reduce sedimentation and erosion. The project area selected for this work plan is the approximate upper half of the Llagas Creek Watershed. It includes all the drainage area tributary to Llagas Creek above the natural confluence with Little Llagas Creek. A work plan for the approximate lower half of the watershed is being prepared for concurrent submittal with this work plan since the two projects are interdependent.

Because urban expansion is imminent, particularly on the valley floor, a 1-percent minimum level of protection was specified through the project area in conformance with California State Soil Conservation Commission policy. There is no area within the floodplain where urban development is not possible by 1985.

The measures selected for achieving the project objective represent the optimum method for alleviating the flood problem. Intensified fire prevention and other land treatment measures are included where they are found to be effective in reducing runoff, erosion, or sediment transport.

The sizing and locating of structural measures consisted of proportioning between flood detention storage and channel improvement, selecting channel alignments, and investigating various diversion schemes. In each case, the measures included within this work plan represents the least costly alternative based on detailed cost studies.

Every effort was made to coordinate all structural works contemplated within this work plan with other existing or proposed projects within or near the project area to assure the full development of the watershed's soil and water resources. The project, as formulated, thus represents the best means available for fulfilling the desires of the sponsoring local organizations based on the experience, investigations and technical knowledge of the various Federal, state, and local agencies consulted in the preparation of this work plan.

WORKS OF IMPROVEMENT TO BE INSTALLED

LAND TREATMENT MEASURES

The land treatment measures selected for this watershed project were those which would have a measurable effect on the production of floodwater or sediment, or in some way complement the function of the proposed structural measures. Most of the land treatment measures, will in some way enhance the vegetative cover. The cover in turn decreases runoff by increasing rainfall interception and decreases erosion by reducing the direct exposure of the soil to the rainfall impact. Examples of these practices are as follows: range proper use, pasture and hayland management, pasture and hayland planting, and range seeding.

Other land treatment measures such as stream channel stabilization, drainage mains and laterals, and irrigation water management alleviate the erosion, sedimentation and drainage problems in the watershed. Critical area planting, grade stabilization structures, and grassed waterways will provide protection to both urbanized areas and land classed as watershed land. These practices are primarily to prevent or to repair damage by gullying.

Conservation plans developed as a result of the cooperative agreements between the Loma Prieta Soil Conservation District and the individual landowners and operators will include the land treatment measures agreed upon for application and will be completed prior to the projects completion. The amounts of land treatment measures to be applied during the project installation period and the estimated costs are shown on Table 1.

Additional land treatment measures to reduce runoff and erosion consist of augmenting the present fire control program to reduce the average annual burn rate from 1.88 to 0.75 percent over a 16,000 acre area in the upper watershed. Specific measures are located on the Project Map. The program will be accomplished by the construction of access roads, firebreaks, helispots, and water tanks. Rights-of-way and technical assistance are also provided.

The entire watershed area is covered by a standard soil survey; therefore no additional funds need be expended in that regard.

STRUCTURAL MEASURES

The plan for structural measures includes raising Chesbro Dam to provide flood detention storage and improving or realigning portions of Llagas Creek and Little Llagas Creek and its tributaries. These measures, in conjunction with the land treatment measures, are designed to provide a 1-percent level of protection against flooding.

The locations of these measures are shown on the Project Map. Cost distribution for each measure is given in Table 2. Other pertinent data, dimensions, and capacities are in Tables 3, 3A, and 3B.

The existing homogeneous earth dam will be raised 11 feet to a new total height of 116 feet above the preconstruction streambed. The additional height will add 3,570 acre-feet of floodwater detention to the reservoir's current 110 acre-feet of sediment storage and 7,520 acre-feet of conservation storage. This will bring the total storage in the reservoir to 11,200 acre-feet. The present sediment reservation will still be sufficient and no change will be made in the conservation storage.

The outlet works will be modified due to the increased height of the dam and subsequent extension of the upstream toe of the embankment. The emergency spillway crest will be 80 feet wide with a 25 foot wide by 12 foot deep notch centered therein to serve as the principal spillway.

This combination spillway will discharge 2,910 cubic feet per second with the water surface at the elevation of the emergency spillway crest and 11,000 cubic feet per second during the freeboard flood. The existing chute has a capacity of 11,000 cubic feet per second and discharges into Llagas Creek immediately downstream from the dam.

The total estimated installation cost for raising Chesbro Dam and modifying the outlet works is $1,153,400.

Channel improvement work on Llagas Creek will consist of improving and straightening 3.8 miles of existing channel generally along the present alignment. An additional 1.3 mile reach of channel east of San Martin has sufficient capacity, but will be maintained as part of this project to insure satisfactory operation of the entire flood channel system. About five miles of Llagas Creek between Chesbro Reservoir and the upstream limit of the proposed works of improvement has adequate capacity to contain the 1-percent outflow from the enlarged reservoir.

Proposed channel sections will range in capacity from 3,430 to 8,900 cubic feet per second, in bottom width from 42.0 to 111.0 feet, and in depth from 7.0 to 8.0 feet. Maximum velocities will reach 8.9 feet per second for the riprap lined channel. Four drainage inlets per mile will be provided for local inflow. These channel improvements on Llagas Creek will alleviate much of the present flood problem by providing a trunk channel with adequate capacity to drain the tributary area.

Installation cost for channel improvement work on Llagas Creek is $1,335,400.

Channel improvement work on Little Llagas Creek and its tributaries will consist of improving, straightening, and realigning 11.2 miles of channel. Of this distance, 10.0 miles will be trapezoidal earth channel with vegetated banks, 0.2 mile will be trapezoidal riprap lined channel, and 1.0 mile will be rectangular reinforced concrete channel. A low flow diversion structure will be installed to maintain normal low flows in an additional 1.2 mile unimproved reach of Little Llagas Creek.

Drainage inlets will be provided on Little Llagas Creek for all improved channels at road intersections and other known points of local inflow. In areas where the location of local inflow is not discernible, eight drainage inlets per mile will be provided. Riprap will be placed at all locations subject to localized erosion such as at transitions, drainage inlets, curves, bridges, and drop structures. Nine reinforced concrete drop structures with folded crests are included to stabilize the channel grade and prevent erosion. The locations of the drop structures are shown on the Project Map and details are tabulated in Table 3A.

The proposed earth channel sections of Little Llagas Creek will range in capacity from 465 to 4,160 cubic feet per second, in bottom width from 4.0 to 65.0 feet, and in depth from 4.9 to 8.0 feet at velocities up to 7.5 feet per second. More detailed information is shown in Table 3B.

The rectangular reinforced concrete channel will be installed in the highly urbanized reaches of Little Llagas Creek through Morgan Hill where it would be uneconomical to acquire the wider rights-of-way required for unlined earth channel. The open rectangular channel will be fenced and double gates at each street crossing will provide access for maintenance.

A reach 115 feet in length is located on a steep side slope. Comparative cost studies show that it is less costly to protect the channel with a cover than to acquire the necessary right-of-way to construct the berm and stable slope that would be necessary to prevent channel blockage from slides. A 189 foot long reinforced concrete box culvert along Second Street was constructed in 1963 and will become an integral part of this project.

The diversion structure will be installed to maintain low flows in the existing stream to satisfy riparian water rights. It will consist of an inflatable and deflatable rubberized fabric dam, 11 feet long at the base and 6 feet high installed on a concrete foundation across the improved channel 1,000 feet downstream from Edmundson Avenue. In the inflated position the dam will raise the channel water surface sufficiently to allow up to 35 cubic feet per second to flow down the existing stream. When the flow reaches 35 cubic feet per second, the dam will automatically deflate and the flow will pass down the diversion channel. After the flood has passed, low flows will again flow down the existing stream by inflating the dam.

Installation cost for channel improvements work on Little Llagas Creek and its tributaries is $2,874,700.

EXPLANATION OF INSTALLATION COSTS

LAND TREATMENT MEASURES

Costs for land treatment totaling $221,600 are found on Table 1. Of this total, $177,900 represents the cost of applying the required measures and will be met by the landowner on whose property the measure is installed. Over the five-year installation period, technical assistance furnished to the soil conservation district will total $43,700 which includes $17,500 from Public Law 566 funds for accelerating the application rate of needed land treatment measures.

Installation costs of land treatment measures excluding intensified fire protection are estimated by years as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	900	10,200	11,100
2	3,500	40,800	44,300
3	7,000	81,700	88,700
4	5,200	61,200	66,400
5	900	10,200	11,100
TOTAL	17,500	204,100	221,600

Costs for land treatment in which the Forest Service will participate are also based on quantities and unit costs with a percentage increase to provide for technical assistance. The total installation cost, exclusive of rights-of-way and easements, is $180,400. Of this total, 50 percent or $90,200 will be borne by Public Law 566 funds, and the remainder will be borne by the sponsors. An additional cost of $63,600 is estimated for rights-of-way and easements and will be borne by the local sponsors.

Installation cost of the planned fire control measures are estimated by years as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	22,600	86,200 *	108,800 *
2	26,700	26,700	53,400
3	16,800	16,800	33,600
4	23,100	23,100	46,200
5	1,000	1,000	2,000
TOTAL	90,200	153,800	244,000

* Includes cost of rights-of-way.

STRUCTURAL MEASURES

The estimated costs of structural measures found in Table 2 are based on quantities calculated as part of the engineering design. The construction cost was determined by multiplying these quantities by unit costs averaged from bid prices within the area and adding a 15 percent contingency factor. This contingency factor is considered adequate because of the detailed surveys, geologic exploration and design work completed for quantity determination. Engineering costs are estimated as 17 percent of the construction cost. Other Federal installation service costs equaling about 5.5 percent of the construction costs are included during the year of construction.

In developing costs for the construction schedule, 70 percent of the engineering cost is assumed to occur in the year preceding construction and 30 percent during the construction year. An additional $5,000 for hydraulic model studies of the spillway design for Chesbro Dam is included in the engineering cost and will occur the year prior to construction.

The above installation services and substantially all of the construction costs total $3,025,900 of which $3,006,700 will be met from Public Law 566 funds. The remaining $19,200 represents the local sponsoring organizations' share of the construction costs for modifying the outlet works on Chesbro Dam and Reservoir and constructing the low flow diversion structure on Little Llagas Creek.

Modification of the outlet works is subject to cost sharing as the relocation of an existing agricultural water management facility. The local share of $11,700 is 50 percent of the construction cost and may qualify for reimbursement by the State of California.

The low flow diversion structure on Little Llagas Creek is subject to the same cost sharing provision since it is required to maintain existing water rights of several landowners for agricultural uses. Fifty percent of the construction cost or $7,500 represents the local share.

Other installation costs include obtaining rights-of-way and easements, relocating or rebuilding bridges, roads and other utilities, fencing, and local administrative cost. A total cost of $996,000 is associated with acquisition of land, easements, and rights-of-way.

A cost of $1,047,600 is associated with relocating or providing new utilities and bridges and includes approximately 6 utility poles, 11 gas mains, 13 domestic water lines, 3 irrigation pipes, 1 telephone cable, and 8 sewer line relocations together with 3 county bridges and 18 private bridges. The cost for these relocations will be met by the sponsoring organizations, but they in turn may be reimbursed by the State of California for all or a portion of these funds.

Local administrative costs of $29,500 for the administration of contracts and State dam filing fees will be borne entirely by the sponsoring organizations. The sponsors will also assume the entire responsibility for fencing the rectangular concrete channel in Morgan Hill amounting to $35,000.

Estimated total expenditures by fiscal years for structural measures are as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	62,700	47,500	110,200
2	520,000	523,200	1,043,200
3	0	0	0
4	99,800	204,700	304,500
5	1,000,200	463,300	1,463,500
6	813,400	630,700	1,444,100
7	721,500	276,500	998,000
TOTAL	3,217,600	2,145,900	5,363,500

EFFECTS OF WORKS OF IMPROVEMENT

The primary effect of the measures proposed within this work plan is to reduce the flooding that otherwise would be expected to cause average annual damages of $376,700. Residual damages are almost non-existent. With the proposed measures, flooding will be associated only with events exceeding that occurring one year out of every hundred on a long-term average, and even this flooding will be reduced in amount.

There would be an area of approximately 2,700 acres benefited. Within this area, the works of improvement would alleviate damages to row crops, hay and pasture, and orchards in the agricultural area and would prevent damages to homes, shops, stores, service facilities and industrial plants in the urban areas.

The project would prevent damages of $73,200 downstream of this watershed. The types of damages would be about the same as within the watershed as the agricultural areas are similar and there are also rapidly expanding residential, commercial, and industrial developments in the Lower Llagas Watershed.

The effect of the works of improvement would be to reduce the danger to public health caused by the presence of floodwaters. Included in this category are the contamination of wells, induced insect breeding, and the disruption of sanitation facilities.

Secondary benefits are quite significant but not subject to rigorous monetary evaluation. A general increase in the level of economic activity will develop as a result of the reduction of the threat of flooding. Increased economic activity in any area raises local purchasing power. Secondary benefits from the national viewpoint were not considered in benefit evaluation.

Presently the floodplain is distributed into approximately 500 agricultural ownerships and at least this many urban ownerships. Counting residents of urban areas, total direct beneficiaries now living in the floodplain number about 5,000 people. Additional direct beneficiaries are found among owners of the industrial and commercial concerns that may be flooded.

Land treatment measures will be effective in reducing sediment production and floodwater runoff. Based on the fire control programs reducing the average annual burn rate in the upper watershed from 1.88 percent to 0.75 percent, sediment production will be reduced by about 10 percent in the area where this program is applied.

In the floodplain area this will effect about a 2-percent reduction in sediment deposition. The decrease in runoff ranges from a 2 percent reduction in flood peaks on the 1-percent hydrograph up to roughly a 10-percent reduction in flood peaks on annual storms. These reductions in sediment production and flood peaks will, of course, have some beneficial effects in the area downstream from the Llagas Creek Watershed.

Special care was taken in the design of structural measures to prevent any detrimental effects to the areas downstream from the proposed structural measures. The measures proposed will not adversely affect and in some cases, will actually enhance these other projects. Special precautions were taken to prevent this project's structural measures from damaging the natural percolation in the channel bottoms.

Channel improvements on Llagas Creek will provide an effective outlet for floodflows from Little Llagas Creek and other smaller tributaries. The increase in flood peaks on Llagas Creek due to channel improvements will be offset by the flood detention storage provided by the enlargement of Chesbro Reservoir.

This plan will have minor influence on wildlife resources. Natural wildlife habitat will be maintained wherever possible. Any reduction of small game that may result where channel improvements destroy natural habitat will be mitigated by planting wildlife food and cover along new banks and levees where feasible. Care will be used in channel maintenance to avoid use of materials toxic to fish and wildlife.

PROJECT BENEFITS

The total average annual evaluated damage caused by floodwaters originating within the watershed is $376,700. This figure includes direct and indirect damages associated with floodwater and sediment in both agricultural and urban areas. Land treatment measures are expected to reduce flood damages by $20,500 annually to leave remaining damages at $356,200. Because all evaluated damages will be practically eliminated by project measures, benefits to be matched against the cost of structural measures equal $382,700 and accrue from eliminating those primary damages described previously under watershed problems, and secondary benefits stemming from and induced by the project.

Agricultural damage prevention due to structural works of improvement would be $15,800 annually due to floodwater damage and $2,600 annually due to sediment damage. These annual benefits would be $14,910 to row crops, $2,210 to orchards, and $1,280 to hay and pasture.

Urban damage prevention would be the annual reduction of floodwater and sediment damages of $131,450 to residential areas, $14,750 to commercial, and $101,600 to industrial enterprises.

Evaluated benefits associated with land treatment measures consist of a reduction in flood damages. Both on-farm and fire control measures enhance cover conditions in the upper watershed and thus reduce sediment and floodwater production. Additional primary benefits associated with the fire control program include the reduction of sediment deposition in Chesbro Reservoir, savings in fire suppression costs, and lessening direct fire damage to property.

Other benefits include a reduction in service interruptions on major communication and transportation facilities as well as such public utilities as gas, water, sewage, and power lines. Interruption of these facilities affects numerous users and, in the case of the highway and railroad lines between San Francisco and Los Angeles, would be extremely critical during a national emergency.

Primary benefits associated with the reduction of damages to farm buildings and property, agricultural equipment, and such public facilities as roads, bridges, and utilities were not evaluated.

COMPARISON OF BENEFITS AND COSTS

Benefits and costs are tabulated and compared on Table 6. Total evaluated average annual equivalent benefits to be achieved by the structural measures are $382,700. This total includes primary and secondary benefits of $356,200 and $26,500 respectively. The average annual equivalent cost of the measures to be installed in order to produce these benefits is $193,800. The ratio of benefits to cost is 2.0 to 1.0. Considering only primary benefits, the ratio is 1.8 to 1.0.

PROJECT INSTALLATION

Each of the sponsoring agencies has and recognizes its definite responsibilities in accomplishing the plan.

The Loma Prieta Soil Conservation District will actively encourage installation of on-farm land treatment measures and assure that the signup of landowners as district cooperators meets the Public Law 566 requirements.

The United States Forest Service and the California State Division of Forestry have entered into a cooperative agreement providing for joint responsibility in planning and executing land treatment measures under Public Law 566. Therein, the State Division of Forestry has agreed to arrange for the installation of fire protection measures on non-Federal forest lands as specified in the watershed work plan.

The State Division of Forestry will enter into agreements with the Santa Clara County Flood Control and Water District. Under this type of agreement, the District may either elect to install the required measures with its own forces or to do it through or jointly with the State Division of Forestry. The District is responsible for obtaining all rights-of-way needed for installation of the fire control measures and also for the local share of the cost of installation as shown in Table 1.

All rights-of-way for designated phases of the fire control program will be obtained prior to commencing construction. The measures will be installed according to the following schedule by fiscal years.

First Year

Construct or improve 7.2 miles of 4-wheel drive road, 3 miles of 75 feet to 150 feet firebreak, 3.9 miles of 75 feet firebreak, and 6 helispots on the north boundary of the watershed project.

Second Year

Construct 11.3 miles of 4-wheel drive road, 11.3 miles of 75 feet to 150 feet firebreak, and 5 helispots along the south boundary of the watershed project.

Third Year

Construct 5.6 miles of 4-wheel drive road, 5.6 miles of 75 feet to 150 feet firebreak, 2.1 miles of 75 feet firebreak, and 1 helispot.

Fourth Year

Construct 1.8 miles of medium standard conventional road.

Fifth Year

Construct three 10,000 gallon water storage tanks.

The Santa Clara County Flood Control and Water District will acquire all necessary rights-of-way and make all required utility relocations and modifications for structural measures. In addition, the District will be responsible for 50 percent of the construction cost of altering the outlet facilities on Chesbro Dam and constructing the low flow diversion on Little Llagas Creek. These construction costs, totaling $19,200 are also subject to reimbursement by the State of California. The District will prepare plans and specifications, award and administer all construction contracts and pay the State filing fees.

The South Santa Clara Valley Water Conservation District will participate in the raising of Chesbro Reservoir and channel improvements in the percolation bed area but will have no direct financial responsibility other than that which may evolve through agreement with the Flood Control District.

All structural measures will be installed by a contractor selected by competitive bidding.

The evacuation of Chesbro Reservoir for construction purposes will not result in any serious loss of usable water. This reservoir and Uvas Reservoir are operated conjunctively with the ground water basin for the Llagas Creek service area. Chesbro Reservoir can be evacuated at the combined discharge rate of both reservoirs. During construction, the entire ground water recharge requirement can be met by increased releases from Uvas Reservoir utilizing the water conserved during the evacuation of Chesbro Reservoir.

The installation of structural measures for the Upper and Lower Llagas Creek Projects will be integrated over a seven-year project installation period. Below is a schedule, by fiscal years, for the Upper Llagas Creek Project.

First Year

Preparation of designs and specifications and acquisition of rights-of-way for all work associated with raising Chesbro Dam.

Second Year

Construction work on Chesbro Dam.

Third Year

No work of improvement.

Fourth Year

Preparation of designs and specifications and acquisition of rights-of-way for channel improvement on Llagas Creek.

Fifth Year

Construction of channel improvement work on Llagas Creek. Preparation of designs and specifications and acquisition of rights-of-way for channel improvements on Upper Little Llagas Creek and West Branch Little Llagas Creek.

Sixth Year

Construction of channel improvement work on Upper Little Llagas Creek and West Branch Little Llagas Creek.

Preparation of designs and specifications and acquisition of rights-of-way for channel improvement on Lower Little Llagas Creek and East Branch Little Llagas Creek.

Seventh Year

Construction of channel improvement work on Lower Little Llagas Creek and East Branch Little Llagas Creek.

The schedule for structural measures shows some construction beginning prior to obtaining total project rights-of-way. This procedure is made possible by the fact that the Santa Clara County Flood Control and Water District has legal authority to exercise the power of eminent domain and, with reimbursement from the State of California, sufficient funds to purchase the required land. The District is aware of its responsibility in this regard and will use its authority and funds as necessary.

FINANCING PROJECT INSTALLATION

All on-farm land treatment measures will be applied by individuals or small groups of landowners. A portion of the installation costs of these measures may be borne by other on-going programs of the U. S. Department of Agriculture including the Agricultural Conservation Program. Loans may be obtained through the United States Farmers Home Administration. Accelerated technical assistance will be provided within the financial framework of Public Law 566. The Service will continue to provide normal operating funds to maintain the going program of technical assistance.

The local share of the installation cost for fire control measures is available from several sources and will be met by the sponsors from direct assessment or by a loan from the Farmers Home Administration. Land, easements, and rights-of-way are also a local responsibility and may be donated by private landowners or obtained by purchase by the sponsors. The State Division of Forestry will provide technical assistance in formulating and installing the measures.

The Santa Clara County Flood Control and Water District will be the action agency for installation of all structural measures. The District has demonstrated its ability to fulfill this role. It has constructed numerous channels in the northern part of the county and recently completed a distribution system for State Water Project water. The District has the technical staff and authority to prepare final designs and specifications, acquire rights-of-way, administer construction contracts, and acquire funds necessary to accomplish this plan.

The Santa Clara County Flood Control and Water District will request funds from the State of California for reimbursement of the cost of rights-of-way and facility relocations under existing state law. The Department of Water Resources has been kept informed of the progress in work plan development and is prepared to support a request for these funds, subject to its detailed review of the work plan.

While it is possible that once installation begins, certain easements or rights-of-way may be obtained by donation from the present owner, no allowances were made for this in estimating the costs. Such donations would reduce the financial obligation of the State or local agency.

The individual sponsoring organizations recognize their total financial obligation and the timing shown in the installation schedule. They are ready, as outlined above, to meet this obligation through local tax funds, credit from the United States Farmers Home Administration, and state reimbursement. These organizations are also aware that the financial and other assistance to be furnished by the United States Soil Conservation Service is conditioned on the fulfillment of the local obligation presented in this plan and contingent upon congressional appropriation of the required funds.

PROVISIONS FOR OPERATION AND MAINTENANCE

Operation and maintenance of on-farm land treatment measures will be the responsibility of the individual landowners on whose property the measure is installed. The Loma Prieta Soil Conservation District and the Soil Conservation Service will provide the technical advice and periodic inspections necessary to insure that the measures are being properly maintained.

The California Division of Forestry has estimated an average annual operation and maintenance cost of $1,800 for the intensified fire prevention phase of the land treatment program. These measures will be operated and maintained either directly by the Santa Clara County Flood Control and Water District, the agency responsible for this function, or indirectly by local fire protection agencies under agreement with the District.

In addition to maintaining the installed measures, proper fire control maintenance includes the prompt emergency treatment of burns on those areas that would produce accelerated erosion, debris production, and increased runoff. For such emergency treatment, state or Federal funds are usually available to assist in watershed restoration.

Operation and maintenance of the flood control facilities at Chesbro Dam and Reservoir will be the financial responsibility of the Santa Clara County Flood Control and Water District, but the actual work may be delegated to the South Santa Clara Valley Water Conservation District, the agency presently operating this facility. An average annual cost of $2,600 has been estimated to represent the additional expenditure for this work.

Operation and maintenance work attributable to raising the dam and modifying the outlet works will include repairs to the concrete structures proposed in the vicinity of the spillway crest, removing floating debris in the reservoir, and maintaining the face of the raised dam. The Santa Clara County Flood Control and Water District will be able to finance this maintenance work by tax revenue sources presently developed.

All channel improvement work proposed in this plan will be operated and maintained by the Santa Clara County Flood Control and Water District at an estimated average annual expenditure of $17,100. The District is presently operating numerous flood channels elsewhere in the county by use of tax revenues and is financially able to expand its program into the watershed.

The estimated cost includes allowances for the materials, labor, equipment, and overhead associated with such channel maintenance work as weed and brush control, rodent control, after flood clean-up, and structural repair to riprap and concrete structures.

Access for maintenance of the concrete lined channel through Morgan Hill is provided at all street crossings. Maintenance roadways are provided along all other improved channels and for the 7,000 feet of unimproved channel on Llagas Creek east of San Martin which will be maintained as part of this project. The South Santa Clara Valley Water Conservation District may share operating responsibilities for those flood channels through their present percolation area.

Inspection of the works of improvement will be conducted in accordance with provisions of the Operations and Maintenance Agreement executed for the works of improvement.

Specific maintenance agreements will be executed prior to the issuance of invitation to bid for any construction contract. The Santa Clara County Flood Control and Water District is fully aware of all its responsibilities in this regard.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Upper Llagas Creek Watershed, California

INSTALLATION COST ITEM	UNIT	NUMBER	ESTIMATED COST (Dollars) 1/		TOTAL
			P.L. 566 FUNDS	OTHER	
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acres	6,862		131,900	131,900
Pasture and Hayland	Acres	1,200		10,300	10,300
Rangeland	Acres	3,000		8,500	8,500
Miscellaneous	Acres	20		27,200	27,200
Technical Assistance	-	-	17,500	26,200	43,700
SCS Subtotal			17,500	204,100	221,600
Forest Service					
Woodland (Fire Control)	Acres	16,000	71,900	71,900	143,800
Land Easements				63,600	63,600
Technical Assistance			18,300	18,300	36,600
Forest Service Subtotal			90,200	153,800	244,000
TOTAL LAND TREATMENT			107,700	357,900	465,600
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structure	No.	1	457,800		457,800
Modification of Outlet Works	No.	1	11,700	11,700	23,400
Low Flow Diversion Structure	No.	1	7,500	7,500	15,000
Stream Channel Improvement	Miles	15.0	2,142,100		2,142,100
Construction Subtotal			2,619,100	19,200	2,638,300
INSTALLATION SERVICES					
Soil Conservation Service					
Engineering Services			453,500		453,500
Other			145,000		145,000
Installation Services Subtotal			598,500		598,500
OTHER COSTS					
Land, Easements and R/W				2,095,400	2,095,400
Administration of Contracts and State Dam Filing Fee				31,300	31,300
Other - Subtotal				2,126,700	2,126,700
TOTAL STRUCTURAL MEASURES			3,217,600	2,145,900	5,363,500
TOTAL PROJECT			3,325,300	2,503,800	5,829,100

1/ Price Base - 1965.

September 1967

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Upper Llagas Creek Watershed, California

MEASURES (1)	UNIT (2)	APPLIED TO DATE (3)	TOTAL COST (dollars) 1/ (4)
Land Treatment			
Conservation Cropping System	Acre	600	$ 600
Cover & Green Manure Crop	Acre	3,000	60,000
Crop Residue Use	Acre	3,400	5,100
Irrigation Water Management	Acre	4,570	22,875
Drainage Main or Lateral	Feet	1,000	200
Stream Channel Stabilization	Feet	4,000	2,400
Pasture & Hay Land Planting	Acre	400	8,000
Pasture Proper Use	Acre	839	1,260
Range Proper Use	Acre	9,000	9,000
Farm Pond	No.	12	12,000
Range Seeding	Acre	30	300
Critical Area Planting	Acre	10	1,000
Grade Stabilization Structures	No.	10	5,000
Grassed Waterway and Outlet	Acre	4	400
Fire Station	No.	1	35,000
Bulldozer and Transport	No.	1	20,000
Helispots	No.	1	450
Water Development	No.	1	500
TOTAL			$ 184,085
Structural Measures			
Agricultural Water Management			
Dams, Reservoirs & Pipeline	Lump Sum	-	$1,572,500 2/
Channel Improvement	Lump Sum	-	600
Flood Prevention			
Channel Improvement	Lump Sum	-	41,500
SUB TOTAL			$1,614,600
TOTAL			$1,798,700

1/ Price Base 1965

2/ Includes 15 percent of Uvas Dam and Reservoir Cost.

July, 1966

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Upper Llagas Creek Watershed, California

(Dollars) 1/

	INSTALLATION COST - PUBLIC LAW 566 FUNDS				INSTALLATION COST - OTHER FUNDS				
		Installation Services							
Structure Identification	Construction	Engineering	Other	Total P.L. 566	Construction	Adm. of Contracts	Easements & R/W	Total Others	Total Installation Cost
RAISING CHESBRO DAM									
Dam & Reservoir - Except Outlet Works	457,800	82,800	25,200	565,800	-	9,200 2/	549,300	558,500	1,124,300
Modification of Outlet Works	11,700	3,900	1,300	16,900	11,700	500 2/	-	12,200	29,100
Subtotals	469,500	86,700	26,500	582,700	11,700	9,700 2/	549,300	570,700	1,153,400
CHANNEL IMPROVEMENT									
Llagas Creek	832,100	141,400	45,700	1,019,200	-	8,300	307,900	316,200	1,335,400
Lower Little Llagas Creek	402,300	68,400	22,100	492,800	-	4,000	411,700	415,700	908,500
East Branch Little Llagas Creek	250,700	42,600	13,800	307,100	-	2,500	250,300	252,800	559,900
Upper Little Llagas Creek	640,400	109,400	35,200	785,000	-	6,500	545,600	552,100	1,337,100
Low Flow Diversion Structure	7,500	2,100	800	10,400	7,500	100	-	7,600	18,000
West Branch Little Llagas Creek	16,600	2,900	900	20,400	-	200	30,600	30,800	51,200
Subtotals	2,149,600	366,800	118,500	2,634,900	7,500	21,600	1,546,100	1,575,200	4,210,100
GRAND TOTALS	2,619,100	453,500	145,000	3,217,600	19,200	31,300	2,095,400	2,145,900	5,363,500

1/ Price Base - 1965.

2/ Includes State Dam Filing Fees.

September 1967

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Upper Llagas Creek Watershed, California

(Dollars) 1/

ITEM	PURPOSE FLOOD PREVENTION	 WATER MANAGEMENT	TOTAL
	Cost Allocation		
Structural Measures			
Raising Chesbro Dam	1,124,300	29,100	1,153,400
Channel Improvement	4,192,100	18,000	4,210,100
Total	5,316,400	47,100	5,363,500
	Cost Sharing		
Raising Chesbro Dam			
Public Law 566	565,800	16,900	582,700
Others	558,500	12,200	570,700
Subtotal	1,124,300	29,100	1,153,400
Channel Improvement			
Public Law 566	2,624,500	10,400	2,634,900
Other	1,567,600	7,600	1,575,200
Subtotal	4,192,100	18,000	4,210,100
TOTAL	5,316,400	47,100	5,363,500

1/ Price Base - 1965.

September 1967

TABLE 3 - STRUCTURE DATA

RAISING EXISTING CHESBRO DAM

Upper Llagas Creek Watershed, California

ITEM	QUANTITY
Drainage Area	18.9 Sq. Miles
Storage Capacity	
Existing Sediment	110 Ac. Ft.
Existing Conservation	7,520 Ac. Ft.
Floodwater Detention	3,570 Ac. Ft.
Total	11,200 Ac. Ft.
Surface Area	
Existing Sediment Pool	15 Acres
Existing Conservation Pool	275 Acres
Floodwater Detention Pool	327 Acres
Elevation Top of Dam	546 Feet
Maximum Height of Dam	
Existing Structure	105 Feet
Raised Height	11 Feet
Total	116 Feet
Emergency Spillway	
Crest Elevation	537 Feet
Crest Width	80 Feet
Type	Concrete Chute
Frequency of Use	1 Percent
Emergency Spillway Hydrograph	(not used) 1/
Freeboard Hydrograph	
Storm Rainfall (6-Hour)	17.5 Inches
Runoff Curve Number (Cond. II)	68
Storm Runoff	13.0 Inches
Maximum Inflow	20,350 cfs
Maximum Outflow	11,000 cfs
Maximum W.S. Elevation	545 Feet
Principal Spillway	
Type	Concrete Chute 2/
Capacity	2,910 cfs
Design Hydrograph	
Maximum Inflow	6,400 cfs
Maximum Outflow	2,910 cfs
Capacity Equivalents	
Existing Sediment Volume	0.11 Inch
Existing Conservation Volume	7.44 Inches
Detention Volume	3.56 Inches
Spillway Storage	3.10 Inches
Class of Structure	C

1/ The emergency spillway hydrograph is considerably smaller than the 1 percent design hydrograph.

2/ The principal spillway is a 25 foot x 12 foot concrete rectangular weir designed as a notch in the weir which forms the crest of the emergency spillway. Both discharge into the existing concrete chute.

July, 1966

TABLE 3A - STRUCTURE DATA

GRADE STABILIZATION STRUCTURES
(Folded Crest Drop Spillway)

Upper Llagas Creek Watershed, California

LOCATION (Station)	DROP (Ft.)	SPILLWAY WIDTH (Ft.) Actual	SPILLWAY WIDTH (Ft.) Effective	DEPTH OF WATER UP-STREAM (Ft.)	CONCRETE (C.Y.)
Lower Little Llagas					
55 + 00	5.5	65.0	57.1	6.6	152
105 + 00	4.2	54.0	46.1	6.6	148
115 + 00	4.0	54.0	46.1	6.6	148
East Branch Little Llagas					
10 + 00	3.0	35.0	25.6	8.0	128
45 + 50	5.0	35.0	25.7	8.0	119
78 + 50	6.0	31.0	24.0	6.0	95
Upper Little Llagas					
12 + 90	4.0	32.0	23.0	8.0	118
208 + 50	3.0	17.5	12.4	4.9	57
223 + 50	3.0	17.5	12.4	4.9	57

July, 1966

TABLE 3B – STRUCTURE DATA

CHANNELS

Upper Llagas Creek Watershed, California

Channel Designation Station to Station	Reach No.	Watershed Area (sq. miles)	Planned Channel Capacity (cfs)	Bottom Width (ft.)	Side Slope	Depth of Water (ft.)	Channel Gradient (ft/ft)	Design Velocity (ft/sec.)
LLAGAS CREEK [1]								
458+00 to 498+15	L-3	58.9	8900	111	2:1	8.0	0.0031	8.8
498+15 to 513+00	L-3	33.9	4920	60	2:1	8.0	0.0030	8.0
513+00 to 580+00	L-3	33.9	4920	85	2:1	7.0	0.0026	7.0
580+00 to 650+00	L-3	33.9	4920	NO CHANNEL IMPROVEMENTS REQUIRED				3.7 to 8.3
650+00 to 687+00	L-3	33.9	4920	78	2:1	7.0	0.0030	7.5
687+00 to 703+70	L-3	33.9	4920	65	2:1	7.0	0.0042	8.9
703+70 to 735+00	L-3	27.3	3430	42	2:1	7.0	0.0045	8.7
LOWER LITTLE LLAGAS CREEK								
0+00 to 6+00	LL-1	20.6 [2]	4160	58	2:1	8.0	0.0017	7.0
6+00 to 32+00	LL-1	17.7 [2]	3630	45	2:1	8.0	0.0021	7.5
32+00 to 52+00	LL-1	17.7 [2]	3630	65	2:1	6.6	0.0021	7.1
52+00 to 121+50	LL-1 & LL-2	13.0 [2]	2940	50	2:1	6.6	0.0023	7.0
121+50 to 220+85	LL-2	4.5 [2]	830	12	2:1	6.0	0.0025	5.8
EAST BRANCH LITTLE LLAGAS CREEK								
0+00 to 10+00	LL-3	8.5	2100	33	2:1	6.6	0.0023	6.8
10+00 to 78+50	LL-3	8.5	2100	20	2:1	8.0	0.0025	7.3
78+50 to 126+70	LL-3	5.2	1300	20	2:1	6.0	0.0031	7.0
UPPER LITTLE LLAGAS CREEK								
0+00 to 11+50	LL-4	4.9	1720	EXISTING LLAGAS CREEK CHANNEL				1.8 to 3.9
11+50 to 46+50	LL-4	4.9	1720	28	2:1	8.0	0.0010	4.9
46+50 to 75+50	LL-4	4.9	1720	21	2:1	8.0	0.0015	5.8
75+50 to 91+50	LL-5	3.2	1130	11	2:1	8.0	0.0015	5.2
91+50 to 130+20	LL-5	3.2	1130	8	2:1	7.6	0.0025	6.4
130+20 to 142+60	LL-5	2.8	870	8	2:1	6.8	0.0025	6.0
142+60 to 173+94	LL-6	2.2	800	10	Vertical	7.4	0.0024	10.8
173+94 to 195+15	LL-6	1.8	640	10	Vertical	6.4	0.0022	10.0
195+15 to 227+35	LL-6	1.4	510	6	2:1	4.9	0.0045	6.6
WEST BRANCH LITTLE LLAGAS CREEK								
0+00 to 17+00	LL-4	1.3	465	4	2:1	8.0 to 5.6	0.0030	2.9 to 5.4

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[1] Equation: 483 + 50 = 487 + 35

[2] Area below Little Llagas Creek Diversion

September 1967

TABLE 4 - ANNUAL COST

Upper Llagas Creek Watershed, California

(Dollars) 1/

EVALUATION UNIT	AMORTIZATION OF INSTALLATION COST 2/	OPERATION AND MAINTENANCE COST 3/	TOTAL
Upper Llagas Creek Watershed Project	174,100	19,700	193,800

1/ Price Base 1965

2/ 100-year amortization period, 3-1/8 percent interest

3/ Adjusted to long-term projected prices

September 1967

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Upper Llagas Creek Watershed, California

(Dollars)[1]

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Agricultural			
Row Crops	12,800	0	12,800
Orchards	1,900	0	1,900
Barley, Vetch Hay & Pasture	1,100	0	1,100
Sub-Total	15,800	0	15,800
Nonagricultural			
Residential	112,450	0	112,450
Industrial	87,000	0	87,000
Commercial	12,750	0	12,750
Sub-Total	212,200	0	212,200
Sub-Total - Floodwater Damage	228,000	0	228,000
Sediment			
Agricultural			
Row Crops	2,110	0	2,110
Orchards	310	0	310
Barley, Vetch Hay & Pasture	180	0	180
Sub-Total	2,600	0	2,600
Nonagricultural			
Residential	19,000	0	19,000
Industrial	14,600	0	14,600
Commercial	2,000	0	2,000
Sub-Total	35,600	0	35,600
Sub-Total - Sediment Damage	38,200	0	38,200
TOTAL DIRECT	266,200	0	266,200
Indirect	37,300	0	37,300
Sub-Total	303,500	0	303,500
Downstream Benefits[2]	73,200	0	73,200
TOTAL NET FLOOD PREVENTION BENEFITS[3]	376,700	0	376,700

[1] Price Base long-term projected level.
[2] Damage reduction from the Lower Llagas Creek Watershed attributed to raising Chesbro Dam.
[3] Damages from floods larger than the 100-year flood will occur but were not evaluated.

July 1966

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Upper Llagas Creek Watershed, California

(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS Flood Prevention Damage Reduction 2/	AVERAGE ANNUAL BENEFITS Flood Prevention Secondary	AVERAGE ANNUAL BENEFITS Total	Average Annual Cost	Benefit Cost Ratio
Upper Llagas Creek	356,200	26,500	382,700	193,800	2.0 : 1.0

1/ Benefits and O & M adjusted to long-term projected prices. Project costs based on 1965 price level.

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $20,500 annually.

September 1967

INVESTIGATIONS AND ANALYSES

PROJECT FORMULATION

This watershed work plan incorporates the practical experience of many people who live within the watershed. The Loma Prieta Soil Conservation District's intimate knowledge of the areas land treatment needs and flood problems, the water management experiences of the South Santa Clara Valley Water Conservation District, and the technical contributions of the Santa Clara County Flood Control and Water District have all greatly facilitated formulation of the work plan.

The technical knowledge of the California Division of Soil Conservation, the U. S. Soil Conservation Service, the U. S. Army Corps of Engineers, the California Division of Forestry, the California Department of Water Resources, and other Federal, state and local organizations has been utilized.

The objectives of the local people are to establish a program of land treatment practices and structural measures that will maintain and protect the watershed, reduce the incidence and hazard of fire, and prevent flooding. Another requirement is that the objectives be accomplished without impairment of the existing facilities for recharging underground aquifers.

The many points of view of the local people were given full consideration in deriving this plan, and as many of their suggestions as could be included within the framework and limitations of Public Law 566 are found herein.

The sponsors and other interested local agencies were kept fully informed of the findings in each stage of project development by the Division of Soil Conservation and were consulted each time a choice among alternative schemes was to be made.

LAND TREATMENT MEASURES

The land treatment measures, with the exception of the intensified fire protection program, were developed by technicians of the Soil Conservation Service and are based on the technical standards that they have developed from years of experience. The basic data consisted of a detailed tabulation of land within the watershed giving land classes, uses and capabilities.

From this an inventory was made of the conservation needs of the watershed area and the corresponding land treatment measures required to fill these needs. Also inventoried were the land treatment measures that have been previously installed (see Table 1A). The list of needed measures was then reduced to include only those that would have a measurable effect upon the production of floodwater and sediment or would be necessary to achieve the full benefit of the planned structural measures.

The total conservation need quantities were next reduced by the amount of practices that could reasonably be accomplished during the project installation period with the optimum technical staff. Land treatment will be applied to more than 50 percent of the farmlands above Chesbro Reservoir. The acres treated and costs are found on Table 1. The accelerated program requires more technical assistance that the present staff can provide during the installation period. Costs for the additional assistance will be met from Public Law 566 funds.

The intensified fire protection program developed by the California Division of Forestry in cooperation with the sponsoring local organizations represents many years of experience of the Division in suppressing fires in this area. The development of the plan called for a careful review of available information on past fire incidence, causes, damages, extent and location of burns, rate of spread, and intensity. The potential fire hazard and risk was determined by evaluating such factors in the existing fire control program as detection, communications, travel times, attack forces, and equipment as to their adequacy based on projected land use.

The objective of project formulation was to reduce the average annual burn rate from the present 1.88 percent to an optimum level considering both the associated benefits and costs. The present burn rate was determined from a study of fire history in the general area of the project to avoid prejudicing the results by temporary local variation within the watershed.

Plans were developed for reducing the burn rate from the present value to 1.75 percent, 1.50 percent, 1.25 percent, 1.00 percent, 0.75 percent, 0.50 percent, and 0.25 percent. To achieve each decrease in burn rate, the plan required additional roads, firebreaks and other facilities. The plan selected is the best buy and preferred by the sponsors. It will reduce the average annual burn rate to 0.75 percent.

The fire protection program includes construction of access roads, firebreaks, water tanks, and helispots. Cost for intensification beyond the level of the going program is shown on Table 1.

STRUCTURAL MEASURES

Principles

The basic objective of the structural works of improvement included in this work plan is to provide, within estimating accuracy, the maximum net flood protection to the watershed without regard to the relative Federal and non-Federal costs and to fulfill, insofar as sound economic and engineering practice will allow, the desires of the local sponsoring groups.

During project formulation, consideration was given to numerous alternative kinds and locations of measures, types of materials, and levels of protection. Care was also exercised to insure that nothing is proposed for the present which would preclude a more comprehensive future development within the watershed. Special caution was exercised to make sure the project will have no adverse effects on future downstream development by the U. S. Army Corps of Engineers.

Scope of the Project

Attention was given to several adjacent watersheds for possible inclusion in this work plan. Where flood problems have been noted, it was found, however, that flood prevention measures could not be justified under Public Law 566 criteria. This work plan covers a portion of the Llagas Creek Watershed called the Upper Llagas Creek Watershed which includes the upper reaches of Llagas Creek and Little Llagas Creek and its primary tributaries.

Alternative Measures

Preliminary to the preparation of this work plan, numerous combinations of channel alignment and detention storage were evaluated for the total Llagas Creek Watershed. The total combined cost of providing flood detention and downstream channel improvement was computed for amounts of flood detention on Llagas Creek up to 5,580 acre-feet. The optimum flood detention requirement is 3,575 acre-feet. Feasible reservoir sites were found only in the Upper Llagas Creek Watershed on Llagas Creek.

Alternative Structure Locations

To determine the best method of providing flood detention storage for the total Llagas Creek Watershed, comparative costs were made on Llagas Creek for an offstream storage site, increasing the capacity of the existing Chesbro Reservoir, and building a new onstream reservoir. In the last case, three possible sites were considered.

When increasing the capacity of Chesbro Reservoir was found to be the most economical choice, further studies were made to find the best method of raising the existing dam and modifying the existing spillway. These studies resulted in the plan to raise the earth dam by placing additional embankment on the upstream face and modifying the entrance to the existing spillway while utilizing its concrete-lined chute.

Numerous different channel locations were analyzed before the final plan was adopted. Improving the existing channel along its present alignment was the first plan investigated. Subsequent analysis consisted of modifying this basic plan to find the least costly alignment. All departures in channel alignment from the existing channel were justified through a detailed cost study.

The most significant change in alignment from the basic plan consists of diverting floodflows originating in the Little Llagas Creek Watershed upstream from U. S. Highway 101 southeasterly into Llagas Creek. Little Llagas Creek between the point of diversion and the Southern Pacific Railroad will require no improvement. By diverting peak flows, the U. S. Highway 101 bridge and the Southern Pacific Railroad bridge have adequate capacities. The bridges on Llagas Creek at these crossings also have sufficient capacities even with the added flow from the Little Llagas Creek diversion.

Little Llagas Creek will be slightly realigned between East Middle Avenue and the confluence with Corallitos Creek will be adjacent to the proposed Route 2 freeway alignment. Shifting the channel alignment west approximately 1,500 feet to be adjacent to the proposed freeway alignment further downstream could not be economically justified.

Lower Little Llagas Creek was diverted to join Llagas Creek immediately upstream from Masten Avenue eliminating the need to improve approximately one half mile of Lower Little Llagas Creek. Various locations for this diversion were investigated before selecting the proposed route.

Other minor deviations from the existing channel consist of straightening the alignment to eliminate numerous sharp curves and routing the proposed channel to follow property lines or avoid valuable land improvements.

Alternative Types of Material

Construction materials to be used in raising Chesbro Dam are largely dictated by existing construction. The dam embankment will remain a homogeneous earthfill, but concrete gravity walls will be added in the spillway area.

Rock riprap lining was used on Llagas Creek in preference to other materials because it was least costly and will minimize interference with percolation.

On Upper Little Llagas Creek through Morgan Hill reinforced concrete lining proved to be the most economical, primarily because of high cost of relocations and rights-of-way required for a trapezoidal earth riprapped or mortar lined channel. Rock riprap lining has been provided for a 1,200 foot reach downstream from the end of the reinforced concrete channel.

Geologic investigations indicate this to be a localized area of erodible soil in which riprap protection is necessary. Further exploration will be necessary to determine the exact limits of channel for which riprap will be required. For all other improved channels, any type of lining is more costly than a vegetated earth channel.

Alternative Levels of Protection

The benefits and costs for various levels of protection were evaluated for the total Llagas Creek Watershed in order to determine the optimum project. The additional benefits and costs associated with each increase in the level of protection were determined and then both plotted against frequency.

The optimum level of protection, defined as the maximum level at which incremental costs equal incremental benefits, was found to be 1.5 percent. However, in order to satisfy the California State Soil Conservation Commission's criterion on minimum level of protection for urban areas, all structural measures in the Upper Llagas Creek Watershed were designed to contain a 1-percent flood.

HYDROLOGIC INVESTIGATION

WATERSHED HYDROLOGY

About 90 percent of the precipitation and all of the historical flooding within the Llagas Creek Watershed have occurred between November 15 and April 15. Average annual precipitation varies roughly with elevation within the watershed and ranges from about 19 inches at the lowest elevations to over 40 inches at the highest. Snowfall is negligible, even at the highest elevations. Flooding within the watershed is almost exclusively associated with cyclonic storms. These storms move in from the Pacific Ocean and generally exceed 12 hours' duration.

The vegetative cover pattern, like precipitation, varies with elevation. The general pattern is row crop farming on the lowest valley lands, orchard within the main valley area, small grain and pasture on the higher valley lands, range land in the foothills, and dense brush and some timber in the higher hills. Percentage of runoff for equal rainfall amounts is substantially higher from the valley areas than from the hills.

Precipitation data from seven gages, including four recording gages within or adjacent to the watershed were analyzed. Data sources included the

U. S. Weather Bureau, the California Department of Water Resources, and the U. S. Army Corps of Engineers. The data were analyzed by the California Department of Water Resources method and agrees with the Weather Bureau findings and the Corps of Engineers Bulletin, "Ten-Year Storm Precipitation in California and Oregon Coastal Basins".

Streamflow records for a five-year period on Llagas Creek and a 27-year period on nearby Uvas Creek were obtained from U. S. Geological Survey records. One-year records at four other points in or near the watershed were obtained from the Department of Water Resources. Because of its longer record, Uvas Creek was used as the key gage from which peak and volume flows for various frequencies were computed.

HYDROLOGY FOR ECONOMIC STUDIES

Analysis of major historical flooding is the basis for the determination of area inundated versus frequency curves. The three basic points used in developing area inundated versus frequency curves were the areas inundated and the associated frequencies for the floods of 1955 and 1958, and the point at which flooding begins, or existing channel capacity as found by a backwater analysis.

Flood data for December 1955 and April 1958 were obtained from field interviews by California Division of Soil Conservation personnel and substantiated wherever possible by photographs taken during the flooding. Flood data were also obtained from the Red Cross, the California Department of Water Resources, the U. S. Army Corps of Engineers, and the Santa Clara County Flood Control and Water District.

The process for determining area inundated versus frequency curves involved developing a peak discharge versus frequency curve from stream gage and rainfall records; determining the frequency of the 1955 and 1958 floods and the beginning of flooding; plotting the data into a peak flow versus area inundated curve; and then relating on a frequency basis area inundated to peak flows.

Data for areas inundated by depth increments were obtained for the 1955 flood by field interview. Total area inundated by floods of different frequency was found through the use of the previously established area inundated versus frequency curve.

HYDROLOGY FOR STRUCTURAL DESIGN

Design hydrographs were computed using methods outlined in the Hydrology Guide.

Various factors used in hydrograph computation, such as time of concentration, curve numbers, and storm distribution curves, were developed by using Soil Conservation Service methods of analysis so that indicated peak discharges, volumes, and hydrograph shapes closely approximated data derived from frequency curves and recorded information.

Design hydrographs, based on the 24-hour storm, were routed through the proposed enlarged Chesbro Reservoir by the storage indication method and through the proposed improved channels by the Wilson method for combining hydrographs to form composite hydrographs for the various design reaches on Llagas Creek.

HYDROLOGIC EVALUATION OF LAND TREATMENT MEASURES

The hydrologic effects of land treatment measures were evaluated by computing their effect on composite curve numbers in accordance with procedures of Section 3.7 of the Hydrology Guide.

Runoff volumes were reduced to show the effect of the curve number change due to land treatment. Peak flows were then proportionately reduced. For economic evaluation these peak flow reductions were translated into area inundated reductions by the same procedure used in computing the original area inundated versus frequency curves.

Fire protection measures were evaluated both with respect to flood peak and to sediment reduction. Flood peak reduction was evaluated by determining the change in runoff curve number by a method developed by the Division of Soil Conservation based on studies conducted by the Pacific Southwest Forest and Range Experiment Station. Change in curve number was translated to area inundated reduction by the process previously outlined for other land treatment measures.

Sediment reduction was evaluated through a similar method based on the same research program. The percentage reduction found from this formula was applied directly to sediment deposition within Chesbro Reservoir and weighted according to the portion of the watershed downstream from the dam requiring fire control measures to determine reduction in the lower watershed.

GEOLOGIC INVESTIGATION

SEDIMENTATION

Reservoir sedimentation in the Chesbro impoundment is proceeding at a slow rate and stream aggradation does not appear to be a watershed problem. There have been thin deposits of silt and fine sand dropped by overbank flow on agricultural lands during floods.

During the investigation it was possible, for a short period of time, to inspect the greater part of the floor of Chesbro Reservoir. There was very little deposition on the reservoir bottom except in pre-existing stream channels. Recent deposition in the channels was spotty and had not exceeded 1 foot in depth over the six years of operation of the conservation pool.

It had been assumed by analogy with known rates in similar watersheds that the rate of deposition would be on the order of 0.2 acre-foot per square mile per year under the existing, relatively low wildfire burn rate in the upper watershed. The additional fire protection to be provided by this project reduced estimated sedimentation rate to 0.12 acre-foot per square mile per year.

There does not appear to be significant long-term aggradation of existing stream channels by transported sediment. Locally, for instance on Llagas Creek immediately above the Highway 101 bridge, there is deposition and/or reduced movement of large gravel due to an abrupt decrease in channel gradient. This accumulation of well-rounded, hard pebbles and cobbles is removed on an intermittent basis for use as road material. Aggradation in other places seems to be the result of sudden constrictions or other temporary impediments to flow causing local scour and erosion. The bed load of Llagas Creek seems to move at such a slow rate that it appears stable. The downstream decrease in average size of bed load material with no local build-up indicates general stability. Many of the larger fragments found in the bed load are probably derived by minor bank cutting from short distances upstream. Erosion of these banks is not excessive and the streamflow is probably in near equilibrium with its bed load.

EROSION

Erosion in the upper watershed is not readily apparent under present excellent cover conditions. Shallow rills can be seen locally, but overall, sheet and rill erosion are negligible. Inasmuch as the upland soils are inherently erodible, an abrupt increase in the annual sedimentation rate would occur following an extensive burn in the watershed.

As mentioned previously, there has been some streambank cutting. It is of minor extent and project channelization will halt this source of sediment.

CHESBRO DAM

Additional investigations will be required for final design of the modifications to Chesbro Dam. These include preparation and evaluation of geologic profiles, delineation and testing of borrow areas, studies of the effects of borrow excavation on the reservoir seal and foundation stability, and detailed studies of the foundation in the right abutment where seepage control will be required.

The right abutment and a portion of the channel section of Chesbro Dam are founded on sheared sediments, chiefly graywacke, of the Franciscan formation. The left abutment and the remainder of the channel section are composed of a fairly massive variety of serpentine containing locally, unaltered pods of the parent peridotite.

Although not ideal foundation material, the stability of the dam at its present height indicates these rocks will support the relatively small surcharge of the additional fill. An evaluation of the logs of the exploratory holes drilled for the original dam corroborates this contention. While some additional settlement of the existing fill material can be anticipated, it is not expected to be of sufficient magnitude to seriously affect either the dam or outlet works.

In the vicinity of the new spillway crest structure, a shallow cutoff will be required in the sheared graywacke. This excavation can probably be ripped and dozed although explosives may have to be used for individual enclosures of hard graywacke or dike rock. Considerable care will have to be exercised in this operation to prevent further shattering of the abutment rock. The graywacke is competent to support the proposed gravity retaining wall.

Material for the additional embankment can be obtained from the floor of the reservoir. The characteristics of the old and new fill will thus be almost identical.

CHANNEL INVESTIGATION

Early in the investigation a few samples were taken from existing streambanks for use in preliminary channelization cost estimates. After the reconnaissance study had demonstrated probable project justification, a program of test drilling was conducted. A total of 24 holes averaging 9 feet in depth were drilled and sampled along proposed channel alignments. Mechanical analyses and Atterburg limits were determined for the 50 samples secured.

Because of an inability to sample gravel strata with the 6-inch flight augers, 13 test pits were later excavated with a backhoe to sample deposits containing large gravel. Mechanical analyses were performed on 18 samples from the test pits. The results obtained from these tests were used to determine allowable velocities and tractive forces in the design of channel improvements. Additional materials investigation will be made in the final design stage to more precisely evaluate required bottom and bank stabilization measures.

MATERIALS

Three potential sources of riprap were investigated: (1) a basalt deposit approximately four miles northeasterly of Gilroy; (2) a high cliff of silicacarbonate rock immediately north of the basalt; and (3) a large existing quarry in Chittenden Pass which produces from a diorite-gabbro body.

It is expected that any of these sources would supply suitable riprap for use as channel lining and as slope protection on the upstream face of Chesbro Dam.

Since there is some question concerning the quantity and blasting quality of the first two of the above sources, detailed exploration of these two potential quarries will be made. If both of these sources prove unsatisfactory, rock may be hauled from the quarry at Chittenden Pass.

The relatively small amount of concrete aggregate required can easily be obtained from any of the several nearly commercial sand and gravel operations. Filter materials can be obtained from the same source.

ECONOMIC INVESTIGATION

GENERAL

Flood damages were calculated to determine benefits from land treatment and structural measures. Depth, area, season occurrence, location, and frequency of flooding were translated into dollar values for agricultural and urban damages. The damages expected under projected land use were evaluated as if no flood prevention improvements were made. The Stanford Research Institute's "A Study of Procedure in Estimating Flood Damage to Residential, Commercial, and Industrial Properties in California" was used to evaluate urban damages. Agricultural and urban damages were combined over a 100-year period to determine the average annual dollar damage. The damage reduction attributed to land treatment was subtracted from the total evaluated damages to arrive at the damages subject to reduction by structural measures. In addition to these damage reduction benefits there are secondary benefits attributed to structural measures. The project benefits and costs were evaluated over a 100-year period using an interest rate of 3-1/8 percent.

LAND USE

The predominant land use of the floodplain presently is agricultural. Principal crops grown in this area of highly productive soil and moderate climate are prunes, grain hay, strawberries, walnuts, grapes and apricots. The majority of these crops are irrigated, mostly by pumped ground water. The City of Morgan Hill and about one-half of the unincorporated town of San Martin are the urban centers within the watershed. Both areas are in the floodplain and are subject to flood damage.

By 1985, the Santa Clara County Planning Department projection shows that these urban centers will have more than doubled in size and increased many times in valuation. "A General Plan for South Santa Clara County", published by the Planning Department, portrays ". . . . a regional city holding 6 separate communities, separated by a common greenbelt of farms and orchards, parks and parkways, and range land." The plan indicates that industrial and commercial development will continue to expand along the valley floor adjacent to the railroad. Residential development will push further west into the uplands thus preserving much of the productive agricultural lands.

The present and projected land uses, as described above, were used in estimating flood damages. Appropriate discounting procedures were used to account for the lag in urban development and phasing out of agriculture on lands taken up by urban uses.

DAMAGE EVALUATION

Types of Damages

Flood damages from inundation and sedimentation were evaluated for agricultural and urban areas under projected development. These damages were evaluated for conditions before and after the installation of land treatment measures. Indirect damages associated with the flooding were included in the total damages to be prevented by the project structural measures.

Consideration of soil structure, flow velocities, cover and the experience of farmers within the floodplain led to the separation of sediment from floodwater damages. Eighty-five percent of the total agricultural and urban damages was attributed to floodwater and 15 percent to sediment. This breakdown of types of damages is consistent with the findings of the U. S. Department of Agriculture in an overall investigation of the Pajaro River Basin in 1952.

Agricultural Damages

Agricultural damages were evaluated through the use of a composite crop acre which was assumed to remain constant throughout the project life. Change, if any, will be in the direction of higher value development and will result in a conservative statement of benefits.

The composite crop acre was determined as part of the present land use evaluation. This composite acre consisted of barley and vetch hay, strawberries, orchard, garlic, beans, sugar beets, and tomatoes.

Representative crop yields and adjusted long-term prices were determined for each of these crops from the annual reports of the County of Santa Clara, Department of Agriculture. Budgets and curves relating net crop income to yield were determined for each crop by use of the above data plus additional information gleaned from interviewing local farmers, the County Farm Advisor, and others acquainted with local conditions.

Direct crop damages were next evaluated from data collected within the watershed on the effects of the 1955 and 1958 floods. Crop budgets and yields were adjusted according to the month of flood occurrence. The results were checked against data collected for similar conditions in neighboring watersheds by other agencies. The damage value for the composite acre was then determined by weighting the value for each crop according to the amount of that crop within the composite acre.

The final step in evaluating agricultural damage was to convert the composite acre values into average annual values. Present (1965) and future (1985) damages were found for floods of various magnitudes by multiplying the composite acre damage by the number of agricultural acres flooded.

By applying an interest rate of 3-1/8 percent and assuming a uniform annual acreage change, these two damage values were combined into a single value for each flood magnitude. A curve showing the relationship of this value with frequency was plotted. Average annual direct agricultural damages were found from the area under this curve. Indirect damages were evaluated as 10 percent of the direct damages. Total average annual direct agricultural damages were found to be $18,400.

Urban Damages

The basic hydrologic data used in evaluating urban damages were areas inundated and depths of flooding. Present and future land use within each depth increment was developed in the land use studies. The basic tool used in calculating damages inflicted by flooding of different depths on urban development was a series of curves developed by the Stanford Research Institute in 1960 for California flooding. These curves give damage per $1,000 of market value for residential, commercial, and industrial properties as a function of depth of flooding.

Market values used for commercial, industrial, and residential development within the floodplain are based on such sources as field data, a study made by the Berkeley office of the Soil Conservation Service on future urban development in Southern California, and data for other similar watersheds. Values for each urban use were further adjusted to obtain averages applicable over the project life. Final per acre values were $60,000 for residential areas, $170,000 for industrial areas, and $247,000 for commercial areas.

The final step in evaluating direct urban damages by converting the per acre values into average annual values was accomplished in the same manner used for agricultural damages. However, in this case indirect damages were assumed to be 15 percent of the direct damages. Total average annual direct urban damages were found to be $247,800.

Unevaluated Damages

Among those damages that were not monetarily evaluated in this investigation were the damages to roads, railroads and public facilities; erosion damages and damages to farm buildings and equipment; the menace of excessive flooding to public health; the detrimental effect of flooding on areal economy; and the disruption of communication and utility services. These damages were not evaluated because additional benefits would have an insignificant influence on both project feasibility and the optimum level of protection.

BENEFIT EVALUATION

Benefits Attributed to Land Treatment Measures

Benefits attributed to land treatment measures were evaluated from the associated reduction in flooded area determined during the hydrologic investigation. The area reductions were translated into monetary values by assuming damages are directly proportional to flooded area. Using this relationship, benefits of $20,500 annually were attributed to land treatment measures before benefits associated with structural measures were evaluated.

There are other benefits due to land treatment measures which were not evaluated. These include some of the benefits due to fire control measures as reduced fire suppression cost and reduced physical loss of trees, fences, homes and other property.

Benefits Attributed to Structural Measures

The total average annual project benefits attributed to the structural measures as shown in Table 6 is $382,700. This total includes $356,200 primary benefits due to flood damage reduction and $26,500 secondary benefits stemming from or induced by the project.

Primary benefits due to flood damage reduction are attributed to channel improvements and raising Chesbro Dam. All benefits associated with channel improvements occur in the Upper Llagas Creek Watershed. Benefits associated with the added flood detention storage in Chesbro Reservoir occur in both Upper and Lower Llagas Creek Watersheds. The total average annual project benefits attributed to the proposed structrual measures within this watershed therefore include $73,200 of flood reduction benefits from the Lower Llagas Creek Watershed.

Secondary benefits attributed to the project were computed in accordance with Chapter 11 of the Economic Guide. The value of local secondary benefits stemming from the project was considered to be 10 percent of the direct primary benefits. Secondary benefits induced by the project were considered to be 10 percent of the project operation and maintenance costs.

While it is recognized that some residual flooding will occur during extreme floods, the amount when brought to an average annual basis is negligible and therefore benefits attributed to structural measures consist of damages remaining after benefits attributed to land treatment measures have been deducted.

SURVEYS

CHESBRO RESERVOIR

"As constructed" drawings of the Elmer J. Chesbro reservoir, dam, spillway, and outlet works together with associated geological exploration served as the basic data for reservoir design. Field inspection of the site provided supplemental information. U. S. Geological Survey quadrangle topography was used to determine rough costs for alternate flood storage sites during project formulation.

CHANNEL IMPROVEMENT

Field cross sections and detailed mapping were provided by the Santa Clara County Flood Control and Water District for Llagas Creek from its mouth upstream to the proposed Little Llagas Creek diversion near U. S. Highway 101, for Little Llagas Creek from its confluence with Llagas Creek to Llagas Road above Morgan Hill, and for East Branch Little Llagas Creek from its confluence with Little Llagas Creek upstream to Tennant Avenue. These sections, following existing channel alignment, were taken wherever significant changes in channel configuration occurred.

Horizontal control was established by a tape transit traverse and vertical control by rod and level using U. S. Geological Survey 1927 North

American mean sea level datum. Topographical data for channels which do not follow existing creeks were obtained from field profiles using rod and stadia control and checked for general conformation with U. S. Geological Survey quadrangle maps of the area.

Scattered cross sections of existing Llagas Creek were taken between U. S. Highway 101 and Chesbro Dam to determine whether or not channel improvement was needed and to design the short reach requiring improvement. All existing bridges were measured in the field in order to determine their present capacities and their influence on channel design and quantities. Utilities crossing or immediately alongside proposed structural measures were located and inspected in the field to determine whether relocation or modification is required.

HYDRAULIC DESIGN

CHESBRO RESERVOIR

All flood routings used in the hydraulic design of raising Chesbro Dam start with the water surface at the crest of the principal spillway when the flood begins. It has been further determined in the geologic studies that an increase in sediment reservation will not be required.

Final sizing of the principal spillway was accomplished by routing the 1-percent inflow for storms of various durations and adjusting the spillway size until the optimum controlled flood storage of 3,570 acre-feet was reached. The 48-hour storm inflow proved to be most critical.

Final sizing of the emergency spillway was accomplished by trial routings of the freeboard hydrograph until the outflow was held to the existing chute capacity of 11,000 cfs. The elevation of the dam crest was placed at the next even foot above highest water surface elevation resulting from this routing. The 6-hour hydrograph was the critical duration.

The proposed 80-foot wide emergency spillway crest will have a 25-foot wide notch in its center to serve as the principal spillway. This control structure will discharge into the existing trapezoidal concrete lined chute with a 25-foot wide bottom and 1.5 to 1 side slopes. Provision is made for model studies in conjunction with final design to determine detailed hydraulic properties of the spillway crest and the curved portion of the chute. Through proper design of the crest, the nominal increase in chute velocities resulting from the greater head can be kept low enough to not materially affect the chute or dissipator operation. Precedence is found for the principle of notching the principal spillway into the emergency spillway from Arnold Dam, built by the U. S. Bureau of Reclamation on the Colorado River in Texas.

CHANNEL IMPROVEMENT

The design water surface elevation at the lower limit of the Upper Llagas Creek Project is established from the design of the Lower Llagas Creek Project. Water surface and channel invert elevations at this point are used as the control elevations for the hydraulic design of the Upper Llagas Creek Project.

Channel design for reaches in cohesive soils is based on tractive force theory. The design relationship used for relating allowable tractive force and plasticity index was developed by the U. S. Bureau of Reclamation and proved applicable to the Santa Clara Valley by evaluating those forces existing channels have successfully withstood. As an additional safety precaution, provision is made for seeding all unlined channels.

A Manning's "n" of 0.030 was used in hydraulic design to allow for vegetation as well as such minor losses as occur at curves and bridge piers. Design velocities have been maintained sufficiently high to prevent excessive sediment deposition and are within the allowable velocities from Figure 6-1 of Soil Conservation Service Technical Release No. 25.

The design of channels for reaches in non-cohesive soils was investigated using limiting tractive force values determined by the method in Technical Release 25 of the Soil Conservation Service. The limiting tractive force values determined for Llagas Creek proved too restrictive to permit the economical use of unlined earth channels.

Geologic investigation indicated that the material in the streambanks is generally poorer than in the bed; and so these channels were designed with riprapped sides and natural bottoms. The tractive forces on the bottom were evaluated by use of methods adopted from Einstein's sediment transport theory and limited to the values given in Technical Release 25 for material of the size of the predicted bed armor coat. The theoretical functioning of the design is for the fines to gradually wash downstream leaving a bed armor composed of the coarsest quarter of the existing bed load material.

On Little Llagas Creek it was possible to use unlined earth channel except for one reach where riprap lining was required. Geologic investigation indicated that the material in the bed of this reach was poorer than in the streambanks, therefore, the perimeter was riprapped. A Manning's "n" of 0.035 which reflects the additional coarseness of bank and bed materials over that found in cohesive soils was used in hydraulic design.

Grade stabilization structures are used in this work plan where they are needed to keep design tractive forces within the allowable limits. Extensive use was made of available literature and recommended Soil Conservation Service criteria in designs for the purpose of cost evaluation.

Reinforced concrete lined channels were designed using a Manning's "n" of 0.014. Channel slopes were designed to limit flows to subcritical velocities. Freeboard was provided in both open and covered reaches in accordance with the Soil Conservation Service's Far West States Engineering Design Standards.

Llagas Creek has sufficient channel capacity throughout a 7,000 foot reach east of San Martin. However, because this reach is an integral part of the channel system upon which the proper functioning of the whole depends, provision is made to maintain it as part of this project. The cost associated with this reach includes purchase of rights-of-way for channel and maintenance roads as well as drainage inlets to bring local inflow into Llagas Creek.

All design flows are in the subcritical range with channel slopes less than 0.7 critical slope.

STRUCTURAL DESIGN

CHESBRO RESERVOIR

Structural design of the raised Chesbro Dam conforms closely with that of the existing structure. The present homogeneous earth section is essentially preserved by placing similar material on the upstream face to achieve the 11 foot increase in crest elevation. An impervious blanket is provided on the right abutment to relieve an existing mild seepage problem.

As the increased storage within the reservoir will only be utilized for periods not exceeding 10 days during major storms, there is no reason to expect any significant effect on seepage or general dam stability. The present slope protection on the dam's upstream face will be removed before additional fill is placed, and higher quality riprap protection will be provided for the raised dam.

The modification required in conjunction with the existing outlet works involves extending the pipe, and relocating the intake structure and oil pump locker. The existing 56-inch welded steel pipe encased in 12 inches of reinforced concrete has sufficient strength to withstand the additional external and internal pressures. The pipe rests on a compacted earth foundation and has experienced some settlement. With the additional fill, settlement should remain too small to affect operation. The outlet works are operated by a gate at the downstream end with emergency closure gates at the upstream end.

Dam foundation work is carried to the same depth used in constructing the existing structure. Stripping is provided wherever new fill contacts the existing ground and includes removal of the existing dam facing. Cutoffs are extended up both abutments to the elevation of the new dam crest.

The existing L-shaped spillway crest is transformed into a straight crest perpendicular to the center line of the existing chute. Gravity retaining walls flanking both sides of the crest are designed to withstand the full hydrostatic head that will develop during the freeboard flood. The walls rest on Franciscan sandstone of sufficient strength to withstand the loading.

CHANNEL IMPROVEMENT

The basic concept used in channel improvement work is to keep the design water surface at or slightly below the existing ground elevation to allow local inflow of storm runoff. Thus, levees are used only across depressions in the existing profile or to provide freeboard. Channel side slopes of 2 to 1 are used throughout the project on earth and riprap lined sections and should present no stability problems. All channel side slope areas not otherwise lined will be seeded and watered until the vegetation is established. A maximum bottom width to depth ratio of 10 to 1 was used throughout the project except for reaches on Llagas Creek within the existing percolation area where a wider channel was required to assure minimum disturbance.

The concrete lined sections were analyzed for structural stability and strength with respect to the hydraulic and foundation stresses created by the proposed design flows. Concrete thicknesses were adopted consistant with Figure 1.10 in the Far West States Engineering Design Standards. Six inches of filter material under the lined section provides for drainage.

Riprap protection is provided for all improved channels on Llagas Creek, at grade stabilization structures, culverts, drainage inlets, existing bridges, major transitions in channel section, channel junctions where not otherwise protected, and a channel reach on Little Llagas Creek where other methods of erosion protection were more costly.

Far West States Engineering Design Standards were followed in establishing riprap thickness and rock size. Six inches of filter material is provided under riprap.

All curves having a radius under 800 feet are provided with riprap protection for earth channels and an increased riprap thickness for channels already lined with riprap. The riprap extends from 1 foot above design water surface to 3 feet below the proposed channel bottom to provide insurance against undermining.

The low flow diversion structure is based on information furnished by the Firestone Coated Fabrics Company.

Grade stabilization structures were sized to provide sufficient quantities for a structurally safe design.

Existing bridges over the improved channels were considered hydraulically adequate if they would pass the design flood with 1 foot of clearance and structurally adequate if the designed channel would not so expose the substructure as to endanger the stability of the bridge. Estimates for new bridges allow a length equal to the design water surface width. The width of the new bridges varies with the type of roadway.

California Division of Highway's standard reinforced concrete box culverts are used where they are more economical than a bridge. Reinforced concrete box culverts were found to be more economical than bridges for discharges less than 2,000 cfs.

Maintenance roadways are provided on both sides of all proposed channels except for areas through Morgan Hill where access will be provided at street crossings.

COST ESTIMATION

LAND TREATMENT MEASURES

The unit costs for installation of on-farm land treatment measures were based on current (1965) costs of materials and construction. For those practices involving farm labor and equipment, costs were derived from recent studies made in the area by the Soil Conservation Service. Construction costs for roads, firebreaks, helispots, and water tanks were based on contract prices for similar work in other areas. Costs of fire control operation and the maintenance of fire control measures were derived from averages of such costs as tabulated in existing records and amount to $1,800 annually.

The cost of technical assistance for the installation of land treatment measures was based upon previous work by State Division of Forestry personnel and an analysis of Soil Conservation Service expenditures and soil conservation district accomplishments for the past several years in the Loma Prieta Soil Conservation District.

STRUCTURAL MEASURES

Construction Costs

Construction costs are based on quantities calculated for the proposed structural measures and estimated average unit costs of the individual items. Unit costs are based on actual bid prices for similar work under comparable conditions in the northern part of Santa Clara County and upon analysis of other applicable cost data which were furnished by various agencies. For some items, such as drainage inlets, unit costs were estimated from tentative designs on a per each basis. The estimated contract costs, based on quantities, were increased 15 percent for contingencies.

Installation Services

A composite installation service cost was estimated as 22.5 percent of the construction cost plus an additional sum of $5,000 for hydraulic model studies for Chesbro Reservoir. The percentage value includes engineering and Federal administrative functions on project, state and national levels. Engineering consists of performing final construction surveys, final designs of structural measures, preparation of plans and specifications, and supervision of construction.

Rights-of-Way Costs

Land values and acquisition costs were provided by the Santa Clara County Flood Control and Water District. They are based on field inspections made by their personnel, sales recently completed in the project area, and the District's recent experience in acquiring rights-of-way for other projects in Santa Clara County.

Rural land values range from $100 per acre for existing creek channel to $8,000 per acre for potential subdivision land. In the urban areas of Morgan Hill, land values within the required right-of-way reach $0.75 per square foot for residential property and $1.00 per square foot for commercial property. All costs are based on fee title acquisition of the required property even though actual construction may be completed on the basis of easements in some instances.

Small buildings, fences and other minor improvements presently located within the required right-of-way are included in the average land values. Improvements of any significant value will be avoided by making slight adjustments in the channel alignment. Property severance was kept to a minimum and bridges are provided where severance cannot be avoided.

The acquisition cost of $1,000 per parcel includes engineering, negotiation and title fees. The number of parcels required was determined from the County Assessor's maps.

Relocation of Road Crossings and Utilities

Unit costs for new bridges were furnished by Santa Clara County and the California Division of Highways. Eight dollars per square foot was used for private wooden bridges and $15.00 per square foot for county and state bridges.

Costs for reinforced concrete box culverts are based on California Division of Highways Standard Box Culverts and unit costs determined for structural measures. The relocation cost of each installation represents the cost beyond the equivalent cost of the channel improvement through the reach. It consists of costs for all required construction items such as reinforced concrete, structural excavation, riprap and roadway paving. The total relocation cost includes 15 percent for contingencies to which 20 percent is added for installation services.

Costs for the two fords across Llagas Creek were determined from preliminary designs and the unit costs used for structural measures.

The cost for road relocations in the vicinity of Chesbro Reservoir was estimated by Santa Clara County based on a feasibility type design and unit costs currently prevailing in the area.

Other utility modification costs (various pipe lines, telephone cables, power poles, wells, etc.) were obtained from the utility company or other owner involved and checked against the experience of the Santa Clara County Flood Control and Water District in relocating similar type utilities elsewhere in the county.

Administration of Contracts

An allowance of 1 percent of the total construction cost is included for the local administration of contracts. State dam filing fees amount to $4,900 and are based on the total construction cost plus 15 percent for installation services of raising Chesbro Dam and modifying the outlet works.

Operation and Maintenance

The estimated annual cost for the operation and maintenance of all structural measures is $19,700. This cost was determined from an analysis of the actual work which will be required to properly operate and maintain these facilities. The analysis was made from the Santa Clara County Flood Control and Water District's cost records for maintaining over 50 miles of flood control facilities and data from other local and state agencies with extensive experience in this field. The annual cost of operation and maintenance adjusted to long-term projected price levels is 0.8 percent of the total construction cost of structural measures.